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A REVIEW OF THE M T C CONCRETE COMPRESSIVE STRENGTH DATA FOR 1984

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

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INTRODUCTION

This report is a summary and discussion of the 28-day compressive strength test data from the 1984 contracts involving concrete work. The data is compared with similar data from 1981 contracts abstracted from a report prepared by G.P. Wilson entitled "Review of the concrete Compressive Strength Data for 1981" and from 1983 contracts in the report " A Review of the MTC Concrete Compressive Strength Data for 1983, MI-64"

The MTC Form 1350, Material Specification for Concrete (Materials and Production), defines a compressive strength test as:

"the average of two standard 150mm x 300mm cylinders cured as per CAN 3A23.2-3C." (1350.08.02)"

For purposes of this report if a strength test result is equal to or greater than the specified strength it is considered to be in compliance. Concrete which meets the acceptance requirements of Form 1350 normally has between 92% and 100% of the test results above the specified strength depending on the standard deviation.

SUMMARY OF RESULTS

A complete listing of the number of cylinder tests, the average strength and the standard deviation for each contract, for all classes of concrete, is in Appendix A.
The following chart summarizes, by region, the total number of strength tests taken and the percentage of tests which comply with the required strength for each commonly used class of concrete.

PERCENTAGE OF CYLINDER STRENGTHS ABOVE OR EQUAL TO THE MINIMUN SPECIFIED STRENGTH (NON-SLAG CEMENT)

	20 MPA		25 MPA		30 MPA		35 MPA	
REGION	# tests	% compl.	# tests	% compl.	# tests	% compl.	# tests	% compl.
CENTRAL	288	99.3	8	100	448	93.1	345	99.4
S.W.	93	100	9	100	78	97.4	17	94.1
N.W.	37	100	-	-	87	90.2	-	-
NORTHERN	62	100	-	-	152	92.1	9	100
EASTERN	79	100	14	100	233	79.0	-	-
PROVINCE	559	99.6	31	100	998	90.0	371	99.2

PERCENTAGE OF CYLINDER STRENGTHS ABOVE OR EQUAL TO THE MINIMUM SPECIFIED STRENGTH (SLAG CEMENT)

	20 MPA		25 MPA		30 MPA		35 MPA	
REGION	# tests	% compl.	# tests	% compl.	# tests	% compl.	# tests	% compl.
CENTRAL	160	98.8	1	100	843	98.7	145	95.9
S.W.	40	100	-	-	45	93.3	11	100
N.W.	7	100	-	-	8	100	-	-
NORTHERN	28	100	-	-	26	100	20	100
EASTERN	34	97.1	-	-	120	89.2	16	100
PROVINCE	269	98.9	1	100	1042	97.4	192	91.1

The following is a comparison of the 1984 total results compared with the results from 1981 and 1983.

COMPARISONS OF COMPLIANCES FROM 1981, 1983 AND 1984
CYLINDER STRENGTH TEST RESULTS (SLAG AND NON-SLAG CEMENTS)

	20 MPA			30 MPA			35 MPA		
REGION	1981	1983	1984	1981	1983	1984	1981	1983	1984
CENTRAL	99.7	100	99.1	90.6	92.0	96.7	94.2	97.0	98.4
S.W.	98.3	100	100	91.2	91.0	95.9	72.7	100	96.4
N.W.	100	97.0	100	78.9	79.0	90.2	-	-	-
NORTHERN	100	100	100	90.9	87.0	93.3	-	-	96.6
EASTERN	100	97.0	99.1	67.5	72.0	82.0	-	100	100
PROVINCE	99.5	99.6	99.3	87.3	86.9	93.7	93.8	97.1	96.4

DISCUSSION

A) 20 MPA

This class of concrete had an excellent compliance in both the slag and non-slag cement categories.

Central region was the only region to have less than 100% compliance with the non-slag cement, at 99.3%. Central and Eastern region had a 98.8% and 97.7% compliance respectively with the slag cement.

The overall compliance for 1984 was about the same as the 1983 and 1981 overall compliances.

During 1981,1983 and 1984 all regions had above 96% compliance for the 20 MPA concrete.

B)25 MPA

Only Eastern, Central and Southwest regions used this class of concrete. With the non-slag cement concrete there was 100% compliance in all regions. Only one test was done in central region in the slag cement category.

Due to the infrequent use of this class of concrete it was not compared with previous years.

C) 30 MPA

This is the most frequently used class of concrete with a total of 2040 tests throughout the province in 1984.

The non-slag cement concrete, with an overall compliance of 90.0% did much worse than the concrete made with slag cement which had a compliance of 97.4%

In the non-slag cement category, Southwest had the best compliance of 97.4% (this was the only region with a compliance over 96%). Eastern region had the worst compliance of 79%.

In the slag cement category Northwest region had a 100% compliance but only 26 tests were performed. Eastern region had the worst compliance of 89.2%.

Although the results of the 30 MPa concrete for 1984 are poor the compliance percentages are much better than the percentages from 1981 and 1983. All of the regions made between 5%-10% improvement over the 1983 results.

D) 35 MPA

This class of concrete was used on all regions except for Northwestern, Eastern region used 35 MPa concrete with slag cement only. All regions had a greater than 96% compliance except Southwestern which had a compliance of 94.1% in the non-slag cement category and Central which had a compliance of 95.9% in the slag cement category.

There was a very slight decrease in 1984 from the overall compliance of 1983. The non-slag cement concrete had a better compliance than the slag cement concrete, this is the opposite of the results with the 30 MPa concrete.

Trial batches are required when 35MPa concrete is used (Form 1350.07.04) this may account for the better quality control and thus a better compliance percentage.

CONCLUSIONS

In general the quality of the concrete used in 1984 was an improvement over the concrete produced in 1981 and 1983.

The 30 MPa class still needs improvement in meeting the strength requirement although this is the most improved class of concrete for 1984. Better quality control and the use of better aggregates may help to improve the quality of the 30 MPa concrete.

The slag and non-slag cements had almost the same overall compliance for the 20 MPa and the 25 MPa concrete. The 30 MPa concrete had a much better compliance with the slag cement while the 35 MPa concrete had a better compliance with the non-slag cement. The type of cement used should have no effect of the strength compliance of the concrete.

APPENDIX A

SUMMARIES OF THE 28 DAY COMPRESSIVE STRENGTHS FOR ALL REGIONS

KEY
n=NUMBER OF TESTS
S.D.=STANDARD DEVIATION
x=AVERAGE STRENGTH

28 DAY COMPRESSIVE STRENGTH TESTS
SUMMARY SHEET

EASTERN REGION
1984

CONTRACT	20 MPA			20 MPA Slag			30 MPA			30 MPA slag			35 MPA			OTHER			
	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	type
1	1	32.9		20	29.7	3.59	18	31.6	3.73	42	33.5	3.93				6	33.9	2.25	25 MPA
	2	31.9	8.44				39	33.9	3.62										
2	7	31.5	5.11				22	33.6	1.77										
3	11	30.4	5.57				75	33.6	4.92										
4	17	27.3	3.31				2	29.4	.95										
5	2	23.8	1.82													4	30.6	3.48	25 MPA
6	3	26.7	2.83				1	30.6											
7	12	26.0	1.24													4	28.2	.88	25 MPA
8	10	29.6	2.59				16	33.5	3.22										
9	2	28.2	.14				26	32.5	4.61										
10	6	31.7	2.10	6	30.5	3.42	12	33.6	3.26										
11	4	26.3	2.24				4	31.0	2.60										
12	2	33.4	5.00																
13										22	35.2	4.51							
14										56	35.9	4.86							
15							4	29.8	4.88										
16							11	34.4	2.40										
17							3	36.7	2.21										
18				8	28.3	2.00										16	38.7	2.12	35 slag

28 DAY COMPRESSIVE STRENGTH TESTS
SUMMARY SHEETS

NORTHERN REGION
1984

KEY
n=NUMBER OF TESTS
S.D.=STANDARD DEVIATION
x=AVERAGE STRENGTH

CONTRACT	20 MPA			20 MPA Slag			30 MPA			30 MPA slag			35 MPA			OTHER			
	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	type
1	23	32.8	3.32				33	33.1	3.70										
	3	28.2	5.37				35	34.0	4.38										
2	3	32.5	1.64				16	34.7	3.93										
							2	36.9	.57										
3							21	37.2	3.59										
							11	37.1	3.37										
4							21	39.9	3.02				9	45.5	4.26				
5	4	32.2	2.28																
6	6	35.0	2.21				13	38.0	3.76										
	18	30.6	2.38																
7	5	30.1	3.33				13	37.4	4.14										
8				15	34.3	2.51				26	36.6	2.69				20	40.2	2.92	35-slag

28 DAY COMPRESSIVE STRENGTH TESTS
SUMMARY SHEET

N.W. REGION
1984

KEY
n=NUMBER OF TESTS
S.D.=STANDARD DEVIATION
x=AVERAGE STRENGTH

CONTRACT	20 MPA			20 MPA Slag			30 MPA			30 MPA slag			35 MPA			OTHER			
	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	type
1	2	28.6					3	34.9	4.80										
2	2	31.1	0.0				5	40.3	6.24										
3	6	27.5	2.50				2	29.6											
4	11	32.2	2.45				25	35.0	3.05										
5	3	33.3	.40				20	37.5	2.87										
6	2	30.2	2.83				6	32.4	2.12										
7	4	36.1	2.3				22	38.9	2.4										
8	7	30.1	3.5				4	34.4	4.8										
9				7	36.4	2.2				8	43.2	4.2							

28 DAY COMPRESSIVE STRENGTH TESTS
SUMMARY SHEET

S.W. REGION
1984

KEY
n=NUMBER OF TESTS
S.D.=STANDARD DEVIATION
x=AVERAGE STRENGTH

CONTRACT	20 MPA			20 MPA Slag			30 MPA			30 MPA slag			35 MPA			OTHER			
	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	type
1				5	33.4	1.06				2	35.6	3.11							
2	6	26.6	3.29																
3	1	33.1					5	32.4	2.08										
4	1	32.4																	
5	9	31.8	2.29																
6				5	33.5	2.76													
7	2	34.3	.07				3	33.7	3.15										
8				4	33.3	2.16													
9				3	30.7	2.84													
10	16	30.9	4.30				7	36.0	4.45										
11	6	32.8	2.32				8	35.5	3.48										
12	6	30.6	2.25													1	29.7		latex
13	6	29.9	4.38																
14				3	31.6	6.18				11	32.9	3.32							
15	1	30.9														8	29.9	3.95	latex
16	19	30.8	2.91				23	36.3	2.71										
17	15	31.7	3.11				21	35.2	1.98				17	41.7	5.26				
18	5	30.0	3.66				9	32.7	2.44										
19				20	36.6	3.90				32	37.4	4.11				11	41.6	2.81	35-slag
20							2	37.8	1.91										
21																9	36.2	3.09	25 MPA

28 DAY COMPRESSIVE STRENGTH TESTS
SUMMARY SHEET

GO-ALRT
1984

KEY
n=NUMBER OF TESTS
S.D.=STANDARD DEVIATION
x=AVERAGE STRENGTH

CONTRACT	20 MPA			20 MPA Slag			30 MPA			30 MPA slag			35 MPA			OTHER			
	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	type
1	33	38.1	3.46	1	36.2		3	35.9	1.27										
2	19	34.5	4.28	7	30.8	3.31													
3	7	35.2	4.80				32	37.2	3.85				1	46.3					
4				2	41.4	6.93				17	39.8	3.04				6	50.4	2.48	35-SLAG
5				13	36.4	5.97													

28 DAY COMPRESSIVE STRENGTH TESTS
SUMMARY SHEET

CENTRAL REGION
1984

KEY
n=NUMBER OF TESTS
S.D.=STANDARD DEVIATION
x=AVERAGE STRENGTH

CONTRACT	20 MPA			20 MPA Slag			30 MPA			30 MPA slag			35 MPA			OTHER			
	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	type
40	18	30.8	4.25				1	30.4								1	35.5		25 MPA
41							7	30.9	2.64	520	38.8	2.40	316	44.1	2.82				
43	12	34.8	2.83										1	45.8					

28 DAY COMPRESSIVE STRENGTH TESTS
SUMMARY SHEET

CENTRAL REGION
1984

KEY
n=NUMBER OF TESTS
S.D.=STANDARD DEVIATION
x=AVERAGE STRENGTH

CONTRACT	20 MPA			20 MPA Slag			30 MPA			30 MPA slag			35 MPA			OTHER			
	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	type
18	6	34.6	5.00				6	35.8	4.38										
19	1	38.3																	
20							1	35.9											
21				10	31.1	1.91													
22	1	32.3																	
23	22	28.5	3.17																
24	6	34.5	3.92																
25	6	37.8	8.88																
26	10	37.8	2.69				4	37.5	2.56										
27	3	37.8	3.12	7	36.5	4.62													
28	9	34.4	2.28	16	35.5	3.55				43	38.6	3.28							
29	3	31.7	11.00	15	34.1	4.61													
30	4	29.0	5.04																
31				10	34.4	3.17													
32	2	32.5	1.06																
34	1	41.0					21	32.2	4.66				8	41.3	4.71	13	23.6	2.30	latex
																2	31.8	8.77	25 MPA
35										55	34.9	4.86				6	28.1	3.82	latex
37										12	33.9	2.10							
38	19	36.5	3.90				33	37.2	4.04				20	43.6	3.70				
39	5	27.2	4.58																

28 DAY COMPRESSIVE STRENGTH TESTS
SUMMARY SHEET

CENTRAL REGION
1984

KEY
n=NUMBER OF TESTS
S.D.=STANDARD DEVIATION
x=AVERAGE STRENGTH

CONTRACT	20 MPA			20 MPA Slag			30 MPA			30 MPA slag			35 MPA			OTHER			
	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	n	x	S.D.	type
1	29	34.0	4.83				118	38.0	4.14							5	36.7	5.25	25 MPA
2							4	38.2	2.82										
3	2	31.8	3.04				13	42.7	3.56	7	34.9	4.70				6	30.0	2.88	latex
4				35	35.0	3.29				45	37.1	3.89				7	42.9	4.65	35-slag
5				29	33.5	3.34				67	40.4	4.22				11	41.8	4.37	35-slag
6	34	33.0	2.93	16	32.6	3.67	91	35.0	4.43	7	40.7	3.08							
7	17	33.7	2.25				19	33.7	4.76										
8	12	35.0	3.56																
9	48	30.4	4.51				106	34.1	3.29							115	41.7	5.62	35-slag
10				7	29.9	6.25				48	39.8	3.71							
11	8	35.4	3.81				8	36.6	3.57										
12				15	35.4	4.39				38	42.6	3.83				12	49.2	2.49	35-MPA
																1	43.9		25-slag
13	2	37.3	4.67				15	33.5	3.91										
15	1	32.5																	
16	5	25.2	1.91																
17	2	34.8	4.88				1	43.0		1	40.5					5	32.2	1.46	latex